User Manual
ULA1

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CATALOG

1 Introduction

ULA1 is a UWB Development module which takes Arduino as the development environment and DWM1000 module of Decawave as the core UWB module. ULA1 can be used for precise ranging, indoor positioning and other high-speed data communication applications. A tyFigureal high-precision positioning system can be achieved by 4 anchors and 1 tag (ULA1 module can be used as an anchor or tag).

The system design is open source. We provide users with embedded source code, hardware schematic, PC software source code, video tutorials and other materials, to help users quickly learning how does the UWB positioning work and getting to work with it.

ULA1 module can be used as an anchor or tag.

HR-RTLS1 is a complete positioning system whicn consists of the combination of 5 or more ULA1 modules.

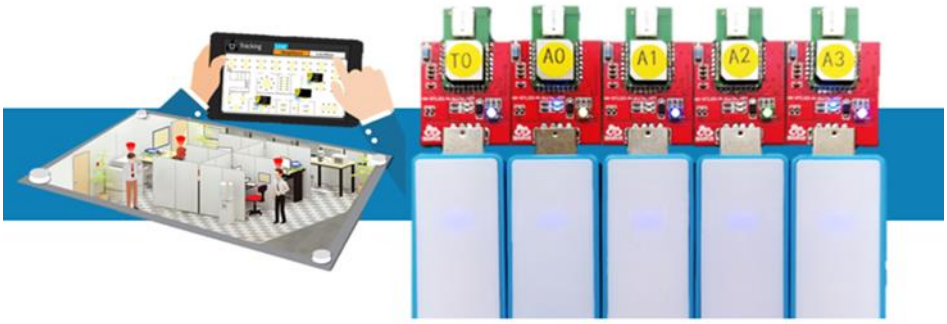


Figure 1-1 ULA1 UWB Module

Table 1-1 ULA1 Module Parameters

Category	Parameter
Module Model	ULA1
Power	DC5V(USB)
Maximum Detection Range	50m (open area)
MCU	ESP32
Development Environment	Arduino
Module Size	40*25mm
Ranging Accuracy	10CM
Working Temperature	-20-80℃

2 Parameter configuration

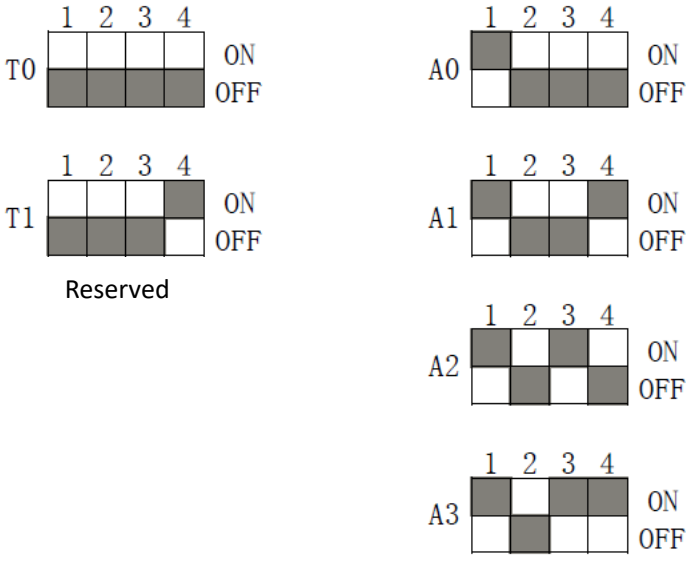


Figure 2-1 DIP Switch Configuration

	S4(Role)	S5-S7 (Device address)
ON	Anchor	Device address 000-111
OFF	Tag	

Table 2-2 DIP Switch Configuration

The 4-bit dip switch is used to conTable the anchors and tags of RTLS positioning system. The minimum system of 3D positioning consists of 4 anchors and 1 tag. The first digit represents the current device role (ON means anchor, while OFF means tag), and the last three digits of the DIP switch represents the current device address.

3 TWR communication protocol

3.1 Structure of positioning frame

The communication data complies with the IEEE 802.15.4 MAC layer frame format. As shown in Table 3-1, A data frame consists of 3 parts-MAC Header (MHR), MAC Payload, and MAC Footer (MFR). MHR consists of frame control bytes, frame sequence number byte and address bytes. The length of MAC payload is variable and can be user-defined. MFR is a 16-bit CRC (FCS) check sequence of MHR and MAC Payload data, which is automatically generated by DW1000.

Table 3-1 Beacon Frame Format

2 bytes	1 byte	2 bytes	2 bytes	2 bytes	Variable length bytes	2 bytes
Frame Control (FC)	Sequence Number	PAN ID	Destination Address	Source Address	Ranging Message	FCS
MHR					MAC Payload	MFR

3.1.1 Frame Control

Table 3-2 Frame Control Type

Frame Control (FC)															
Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8	Bit 9	Bit10	Bit11	Bit12	Bit13	Bit14	Bit15
1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1
Frame Type			SEC	PEND	ACK	FIGURE	Reserved			DestAddrMode		Frame Version		SrcAddrMode	

Table 3-3 Frame Type

Frame Type Field (FC bits 2 to 0)	Frame
0, 0, 0	Beacon
0, 0, 1	Data
0, 1, 0	Acknowledgement
0, 1, 1	MAC command
1, 0, 0	Reserved
1, 0, 1	Reserved
1, 1, 0	Reserved
1, 1, 1	Reserved

Table 3-4 DestAddrMode Meaning

Destination addressing mode (FC bits 11 & 10)	Meaning
0, 0	No destination address or destination PAN ID is present in the frame
0, 1	Reserved
1, 0	The destination address field is a short (16-bit) address.
1, 1	The destination address field is an extended (64-bit) address.

Table 3-5 SrcAddrMode Meaning

Source addressing mode (FC bits 15 & 14)	Meaning
0, 0	No source address or source PAN ID is present in the frame
0, 1	Reserved
1, 0	The source address field is a short (16-bit) address.
1, 1	The source address field is an extended (64-bit) address.

3.1.2 Sequence Number

NOTICE: Incremented by 1 for each time.

3.1.3 PAN ID

NOTICE: Data receiving device and data sending device must be the same PAN ID to successfully receive and send data.

3.1.4 Destination Address

NOTICE: N/A

3.1.5 Source Address

NOTICE: N/A

3.1.6 FCS

Frame Check Sequence (FCS)

NOTICE: Data checking, which is automatically calculated by DW1000.

3.1.7 Ranging Message

3.1.7.1 POLL Message

1 byte
Function Code
0x80

3.1.7.2 Response Message

1 byte
Function Code
0x81

3.1.7.3 Final Message

1 byte	5 bytes	5 bytes	5 bytes

Function Code	Poll TX time	Resp RX time	Final TX time
0x82	-	-	-

3.1.7.4 Report Message

1 byte	2 bytes
Function Code	Distance
0x83	-

3.1.7.5 RangeData Message

1 byte	2 bytes	2 bytes	2 bytes	2 bytes	1 byte
Function Code	Distance A0	Distance A1	Distance A2	Distance A3	Range Mask
0x84	-	-	-	-	-

4 Serial communication protocol

Example： mc 0f 00000663 000005a3 00000512 000004cb 095f c1 0 a0:0

Table 4-1 Serial Communication Protocol Description

Content	Example	Description
HEAD	mc	Head of the data packet，fixed：” mc”
MASK	0f	If ranging results are valid. For example: mask=0x07(0000 0111) means RANGE 0,1,2 is valid.
RANGE0	00000663	Distance from tag to anchor A0，hexadecimal notation， unit: mm，result of the example is 1.635m.
RANGE1	000005a3	Distance from tag to anchor A1
RANGE2	00000512	Distance from tag to anchor A2
RANGE3	000004cb	Distance from tag to anchor A3

NRANGES	095f	message flow, accumulated， 0x0-0xffff
RSEQ	c1	Range number, accumulated， 0x0-0xff
DEBUG	0	Reserved, for debugging.
rIDt:IDa	a0:0	r means the role: a-anchor， t-tag; IDt-tag address， IDa-anchor address

Supplementary instruction of rIDt:IDa:

If the current anchor is connected to PC:

r=a indicates the current role is anchor;

IDt indicates the tag ID, and it shows which tag is ranged by the current anchor;

IDa indicates the anchor ID, representing the anchor ID that connecting to the PC

Example:

1, anchor A0 connects to PC, and tag T0 is powered on [a0:0]

2, anchor A0 connects to PC, and tag T1 is powered on [a1:0]

3, anchor A1 connects to PC, and tag T1 is powered on [a1:1]

r=t indicates that it is a tag connecting to PC;

IDt indicates the tag ID, and ":0" is fixed behind the IDt.

Example:

Tag T0 connects to PC, and anchor A0 is powered on [t0:0], then RANGE0 has an output value.

5 TWR ranging process

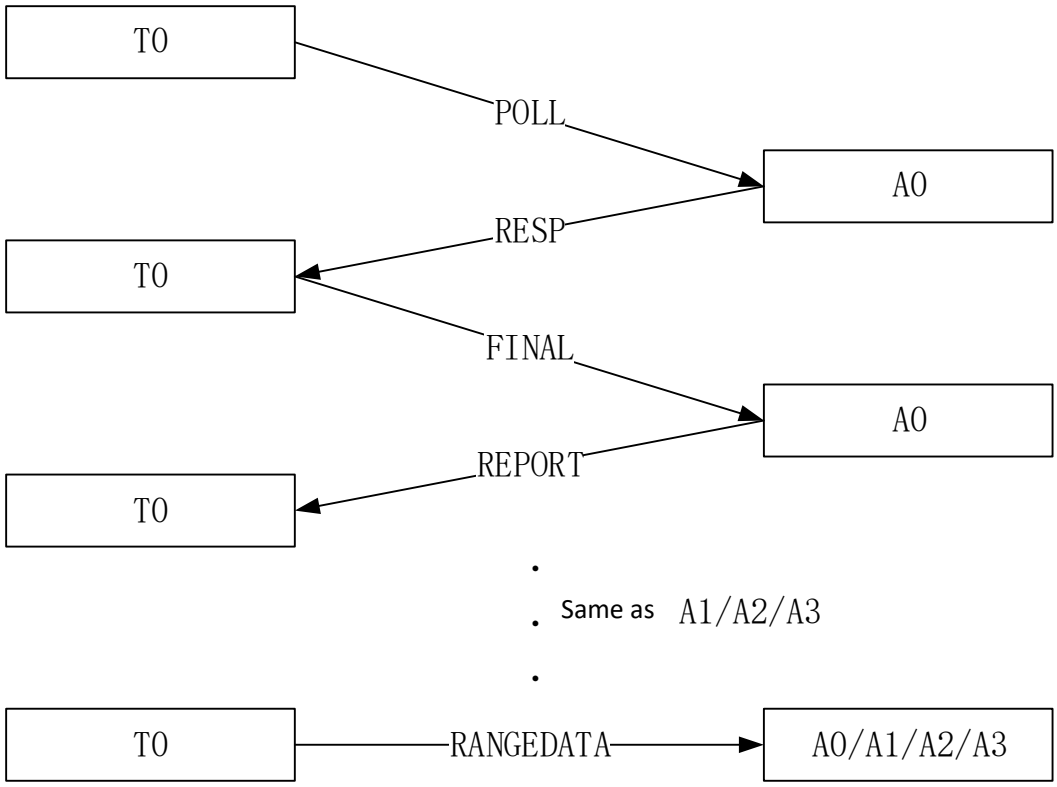


Figure 5-1 TWR Ranging Process

If RangingTag or RangingAnchor program is in process, the entire ranging cycle is completed after TWR ranging from T0 to A0 is executed once.

If RTLS_Tag or RTLS_Anchor program is in process, the entire ranging cycle is completed after finishing the TWR ranging to A0\A1\A2\A3 continuously, and broadcasting a RangeData message.

6 System deployment

There are two system deployment modes: navigation mode and monitoring mode. During the navigation mode, the tag needs to be connected to the PC while other anchors only need to power on. The position data and real-time track of the currently connected tag can be displayed on the PC software. In the monitoring mode, one of the anchors is connected to the PC, while the other anchors and labels are powered

on. The position data and real-time track of all labels in the coverage area of the current anchor can be displayed in the PC software.

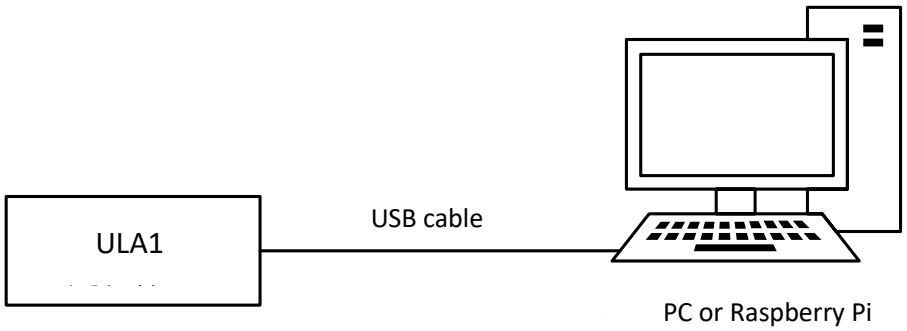


Figure 6-1 Module Connects to PC

For the initial utilization, **CP2102** driver should be installed at first. After identifying the serial port on the PC, please open the PC software, select the serial port, and click "Connect" button to complete module connection and data communication.

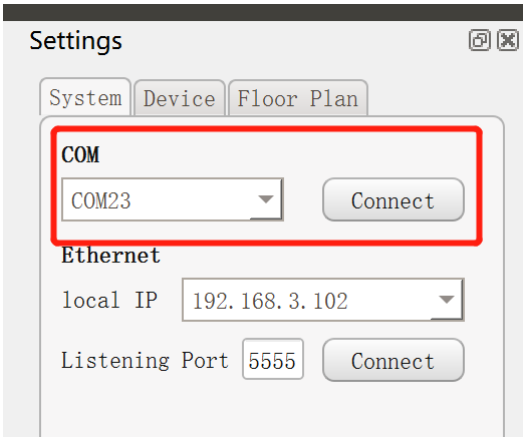
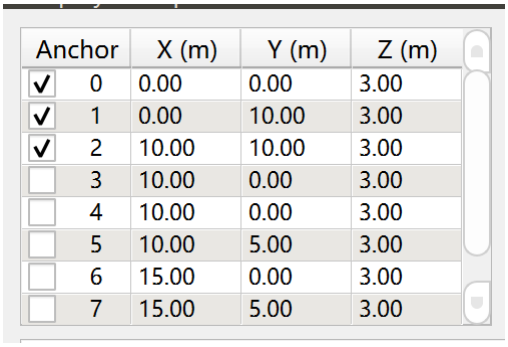


Figure 6-2 Serial Port Connection

After successfully connecting, users can complete the equipment deployment by configuring the position coordinates of the anchors based on the relative position of the anchors, and then the tags can be located and displayed.



Anchor	X (m)	Y (m)	Z (m)
☑ 0	0.00	0.00	3.00
☑ 1	0.00	10.00	3.00
☑ 2	10.00	10.00	3.00
☐ 3	10.00	0.00	3.00
☐ 4	10.00	0.00	3.00
☐ 5	10.00	5.00	3.00
☐ 6	15.00	0.00	3.00
☐ 7	15.00	5.00	3.00

Figure 6-3 Configure the Coordinates of Anchors

For more details about the utilization of system deployment, please download the <HR-RTLS1 UserManual-EN> to get more information.

Download HR-RTLS1 UserManual：

http://rtls1.haorutech.com/download/HR-RTLS1_UserManual-EN.pdf